

Animal white; tentacula fifty to fifty-four. Calyx festooned.

Statoblasts elliptical, yellow, with a narrow blackish ring dividing the cell from the narrow purple rim or annulus which surrounds it. The cell is beautifully reticulated externally. Two out of the three statoblasts observed had a slight constriction on one side, which gave them a slightly reniform outline.

Habitat. On an old valve of *Anodon cygneus*, in the canal, Exeter, June 23, 1866.

This appears to be a very distinct species, and is allied or, rather, belongs to that section of the genus to which *P. emarginata* belongs, viz. with a line or ridge along the upper part of the diaphanous tube. But the line of demarcation between the diaphanous portion of the tube in this species and the thick opaque walls of the inferior half gives it, even at first sight, a very distinct and marked appearance. Another striking peculiarity is that the tubes grow mostly in pairs, and are very closely adherent to the matrix, except the polype-cell, which stands up conspicuously near the end of the tube.

Length of the cœnœcium 10 lines.

EXPLANATION OF PLATE XII.

Fig. 1. *Plumatella lineata*: cœnœcium, nat. size, or 2 inches in its longest diameter.

Fig. 2. A portion of the same, enlarged, showing the animals protruded, and one partly withdrawn within its cell.

Fig. 3. Statoblast.

Fig. 4. *Plumatella Limnas*: cœnœcium, enlarged.

Fig. 5. Polype-cell, showing its position at the end of the tube.

Fig. 6. Showing the true polype-cell within the ectocyst.

Fig. 7. The polype expanded.

Fig. 8. Statoblast.

XXIX.—*On the Classification of Buprestidæ and Elateridæ, with special regard to the Danish Fauna.* By Prof. J. C. SCHIÖDTE*.

I.

By the well-known and valuable researches of Eschscholtz (published in Thon's 'Entomologisches Archiv,' ii., and in Silbermann's 'Revue Entomologique,' vol. iv.) attention was drawn to a great number of hitherto unobserved points in the external structure of Elateridæ, on which he founded an artificial classification of that family; and since then, the remainder of Latreille's *Sternoxi* have been subjected by other entomologists to an analogous examination, resulting in the establishment of more than

* Translated from 'Naturhistorisk Tidsskrift,' ser. 3. vol. iii. Copenhagen, 1865. Accompanied in the original with a plate representing the organs of the mouth.

300 genera. The usefulness of this work in procuring at any rate a temporary survey of the extensive collections which have accumulated in museums cannot, of course, be doubted; but at the same time it is but too apparent that this method is entirely insufficient whenever it is attempted by its means to establish and satisfactorily circumscribe natural groups. Not even for the distinction of the two great natural families of Buprestidæ and Elateridæ have truly scientific characters been forthcoming; it has been found necessary to adopt a number of unsatisfactorily characterized groups, forming, as is supposed, links of transition between them; and the characters which at length have been fixed upon as the most distinctive and most generally valid are, as will be shown hereafter, unstable both in theory and practice, and unable to stand the test either of morphological criticism or of careful examination. Two excellent entomologists have engaged in the study of Elateridæ, in order to bring about a more natural view of the relationships; I mean Germar and Erichson: but, as Lacordaire observes, both have evidently given it up in despair; and the last-named author himself, after long-continued and careful investigations, cannot suggest any other remedy than, as he expresses himself (*Genera des Coléopt.* iv. p. 137), "to let tradition make up for the inability of science to master the subject."

Lacordaire's summary of the earlier investigations, and his general view of the structure, development, and habits of *Sternoxi*, reappears, in all essential points, together with many valuable contributions of detail, in the extensive and independent treatises on these families which have appeared during the last few years from the hands of Leconte*, Kiesenwetter†, Thomson‡, and Candèze§. In this manner certain views concerning the principal points in the natural history of these animals have been temporarily established by the repeated examination and assent of the greatest modern authorities in this department.

II.

If we attempt to extract from all these sources the essence of the information they offer concerning the larvæ of Buprestidæ and Elateridæ, the result may be thus summed up.

The larvæ of Buprestidæ are soft, elongated, blind, apod, and live burrowing in timber. Their prothorax is discoid, laterally distended, their head divided into two parts, of which the smaller

* Classification of the Coleoptera of North America, Part 1. Washington, 1861-1862.

† Naturgeschichte der Insecten Deutschlands, iv. Berlin, 1858.

‡ Skandinaviens Coleoptera, synoptiskt bearbetade, vi. Lund, 1864.

§ Monographie des Elatérides. Liège, 1857, &c.

anterior part carrying the organs of the mouth is chitinized, whilst the larger posterior part containing the mandibular muscles is soft and retractile within the prothorax. In some, however, as in the larvæ of *Diphucrania* (New Holland), the prothorax is not distended; and the larvæ of *Trachys*, which live in the parenchyma of leaves, where they excavate their burrows, are said to have hard dorsal and ventral shields, free head, two eyes, and short legs.

Similar to the larvæ of Buprestidæ are those of Eucnemidæ. The larva of *Melasis* is only distinguished by the structure of the mouth, and by the head consisting of one piece only. The mandibles are not chisel-shaped, as in the larvæ of Buprestidæ, but short, turned outwards, with a hook on their external margin, close behind the point; and the other buccal organs, which are free in the larvæ of Buprestidæ, are in that of *Melasis* represented by a small plate serrated in front. It is said to live in fresh timber, forming long irregular galleries, with entirely smooth and even walls, a piece of the burrow being rounded off in the shape of a cylinder for the accommodation of the pupa. At the same time, exceptions occur in the group of Eucnemidæ as in that of Buprestidæ, the larva of *Fornax madagascariensis* being, according to Coquerel, flat, depressed, and hard, the prothorax not distended, the head hard, flattened in front, with a serrated edge, without perceptible organs of the mouth—nay, without a buccal orifice; the larva burrows in timber, as that of *Melasis*.

Entirely different from these are the larvæ of Elateridæ. They are long, slender, with a hard skin, cylindrical or a little depressed; the mandibles are hooked and pointed, with an interior tooth; the maxillary lobes and palpi are distinct, the maxillæ coalesce with the labium into one piece; the legs are short and powerful, and the last joint of the body often furnished with prominent teeth. They are supposed to live on vegetable matter, many on decaying timber; sometimes, however, they feed on the other larvæ they happen to fall in with. For more than a century the larvæ of *Agriotes* have been known as dangerous enemies of several cereals, leguminous and other agricultural plants, of which they attack the roots.

Such is a summary of what science hitherto has taught us as to the history of these larvæ; but it is quite clear that these statements do not afford the materials for an accurate estimation of the systematic relationships of these creatures. Nay, these statements even contain several details which, on closer examination, cannot but excite doubt and suspicion, and stimulate to new investigations.

This applies, in the first instance, to the statement that in the larvæ of Buprestidæ the mandibular muscles are not, as usual,

fixed to the firm sides of the head, but pushed back into a peculiar kind of soft bag behind the head. If anybody were to state that he knew of a group of Rodentia whose jaw-muscles were not fixed to the sides of the skull, but accommodated in a membranaceous appendage behind the occiput, the absurdity would be apparent to every one; but that statement concerning the mandibular muscles of the larvæ of Buprestidæ implies a difficulty if possible still greater. For as their hard mandibles are articulated on the firm framework of the mouth by means of complete cardinal joints, the necessity for a firm support for the moving muscles is still greater than in Rodentia. The difficulty is, moreover, enhanced by the fact that the membranaceous part of the head with the mandibular muscles, when compared with the smaller anterior part containing the organs of the mouth, in shape and size appears as a larger circle placed behind a smaller one, from which it follows that the relative position of the base of each mandibular muscle and the inner angle of the mandible, or the point on which the tendon must join the mandible, must be such that a muscle thus placed could not inflect the mandibles unless the tendon went through a pulley. But such a pulley-arrangement would seem inapplicable where so great a force is required as is the case with chisel-shaped instruments destined in many cases to be used as pincers to detach piece after piece of sound timber.

This account, which it seems so difficult to reconcile with general truths, is mainly due to Prof. Erichson (in *Archiv für Naturgeschichte*, 1841, i. p. 81), and it has met with universal assent as the only true solution of the problem (which is certainly not very easy) how to interpret the peculiar-looking front part of the body of the larva of Buprestidæ. Before him Löw had turned attention to the matter, asserting (in *Entomologische Zeitung Stettin*, 1841, p. 35) that the larvæ of *Chalcophora*, "as those of all Buprestidæ, are distinguished by the extension of the prothorax, which is rendered necessary for the reception of the enormous mandibular muscles." Löw, therefore, agreed with Ratzeburg in assuming that not the head, but the prothorax, was divided into two parts, of which the anterior part was soft, the posterior endowed with hard skin. Against Löw, Erichson urged the great anomaly of the mandibular muscles being placed in the prothorax; and it seems that this consideration more than any other has led him to the new interpretation which is now generally adopted; for in favour of this he appealed to the fact that the muscles in question did not, as Löw thought, fill the whole prothorax, but only its anterior soft portion, which he therefore considers to be part of the head, while he considers that part of the body which Ratzeburg and Löw looked upon as

the whole head to be merely a firm framework for the mouth. The correctness of this view is generally assumed. Chapuis and Candèze concur in it entirely, and even try to support it by an additional argument, which I cannot but think is of very doubtful value—namely, that the head must have soft integuments for the purpose of being retracted into the prothorax*. On the subject of Goureau's theory†, according to which the whole of the prothorax becomes head, Lacordaire observes that it does not deserve refutation, that moreover it has been sufficiently refuted by Léon Dufour and Perris; he considers Erichson's interpretation so decidedly true that he looks upon that of Ratzeburg and Löw as an almost inexplicable error (*Genera des Coléopt.* iv. 7. 1).

Nevertheless Erichson's theory offers, as we have seen, insuperable difficulties in a physiological point of view; and it seems to be quite worth our while to try whether the matter may not be differently regarded. Let us, then, first of all try to realize fully the conditions under which the larvæ have to exist in the interior of the timber, and compare the structure of other larvæ burrowing in wood, particularly the apod larvæ of Cerambycidæ; we shall then soon arrive at two important conclusions. In the first place, the mandibles must possess extremely powerful flexors, which consequently must be too large to find room in the proportionally small part which has hitherto been looked upon as forming the whole head in the larvæ of Lamix and Buprestidæ; in the second place, the great demands upon the power and endurance of these apod larvæ cannot be satisfied by the strength of the mandibular muscles alone, however great; but power and accuracy in the guidance of the head—that is, in the application and pressing of the mouth against the timber during the act of burrowing—is required in no less degree. In these sentences lies the key of the whole complicated arrangement. A careful dissection will show, what is sufficiently surprising, that no one has hitherto had an accurate idea of the real extent, shape, and position of the head in the larva of either Lamix or Buprestidæ. The fact is, that the protruding anterior part of the head is uninterruptedly continued backwards into a very large skull, which, in the larvæ of Buprestidæ, is so large that it actually reaches the very bottom of the prothorax, so that the neck is on a line with the first pair of

* “En effet, dans ces larves la plaque sous-céphalique, cornée à sa partie antérieure, est devenue très-molle dans le reste de son étendue, parce qu'elle doit se replier sur elle même pour rentrer avec les parties de la bouche dans la gaine que lui forme le prothorax.” (Chapuis et Candèze, *Catal. des Larves de Coléopt.* pp. 131, 132.)

† *Ann. de la Soc. Ent. de Fr.* sér. 2. vol. i. p. 26.

spiracles. With the exception of the middle line, this large head will be found filled by the powerful flexors of the mandibles, reaching to the foramen occipitale, which is very large and entirely transferred to the under surface of the head. The head, then, is for the greater part hidden in the prothorax as in a sheath, fixed all around and directed by the powerful muscles of the neck. The whole of the part which is placed inside the prothorax is only sparingly chitinized; but the action of the muscles of the neck extending between the outside of the skull and the walls of the prothorax makes up for any loss of support which could arise to the mandibular muscles from the want of hardness in the skull. During the act of burrowing, the prothorax is firmly ensconced between the walls of the gallery, the numerous grains of chitine with which its surface above and below is generally beset increasing the firmness of its position; and thus every requisite condition is provided—a firmly placed prothorax affording support for the muscles of the neck in guiding the head forwards and backwards and to the sides, and the skull inserted as in a sheath giving support to the enormous mandibular muscles.

The immense size of the head and its deep insertion into the prothorax, of course, are the causes of the peculiar shape and unusual size of the latter part, which has further contributed to confound the views of entomologists on the structure of the larvæ of Buprestidæ*. It has been overlooked by all that in this case one part of the prothorax is developed at the cost of the others—namely its anterior portion, the so-called collar (collare prothoracis), which is found in all larvæ and all imagos of insects with more or less inserted neck, but which in the larvæ now before us is immensely increased in size. In my paper on the larvæ of Coleoptera, published in the 'Naturhistorisk Tidsskrift,' I describe the dorsal part of this collar as prætergum pronoti. The rest of the prothorax, which is elsewhere much the larger, and which serves the locomotory system by accommodating the fore legs, is in this case to such a degree reduced that it seems to be entirely wanting, and the large spiracula thoracica have not been able to find room as usual on the prothorax, but have been transferred to the lateral folds of the next ring, pleuræ mesothoracis. The larvæ of *Trachys* being described as possessing a free head and short legs, it will, no doubt, be found that the larvæ of Buprestidæ will show the same

* In the Mém. de l'Acad. des Sc. de Lyon, 1851, pp. 116–120, M. Perris has given a minute summary of the discussion between Gonreau, Lucas, and Léon Dufour on this subject. Although each of the four authors now and then has got hold of the clue for a moment, they have always lost it again, and none of them has succeeded in solving the problem.

series of forms as those of Cerambycidæ, but in a less degree. In these latter the collar of the prothorax varies not a little in extent according to groups and genera, the head being in some cases deeply inserted into the prothorax, in others tolerably free; but, in all of them, so much at least of the principal portion of the prothorax remains that, at any rate on the underside, it appears as a transverse fold which carries the short legs when such are found. To the larvæ of Lamia correspond those of Buprestidæ, to that of *Trachys* the larvæ of Lepturini, in which the head is sometimes so little inserted that it seems to betray a relationship to those larvæ of Curculiones which burrow in timber. When the head occupies such a position as in the larvæ of Buprestidæ, being inserted in the prothorax, the skin of the neck must necessarily be very full, in order to afford the necessary play for the protrusion and retraction of the head; and in proportion as the insertion of the head is deeper, the skin of the neck is fuller and more protruding.

It will now appear that although none of the theories above mentioned have hit upon the facts, they all contain in some way an element of truth. Löw's view is purely anatomical, and although wrong in a morphological sense (because the mandibular muscles cannot well be situated in the prothorax of any insect with articulating mandibles), yet it is so far true that the head which contains them is itself imbedded in the prothorax; what Löw has overlooked is the walls of the head. Goureau's view is, so to say, that of common sense unshackled by anatomical or morphological scruples; and from such a point of view the prothorax might be called the head with perfect justice. Erichson's view is learned and critical, with a theoretical element inviting attention, but is neither probable in a physiological point of view nor true in point of anatomy; it has therefore less of body or soul than either of those it attempts to reconcile. What he considers the hind part of the head is merely the distended skin of the neck.

III.

The striking external similarity between the larvæ of *Melasis* and those of the Buprestidæ has not only served as a principal argument for looking upon *Melasis* as a connecting link between Elateridæ and Buprestidæ, and thus exercised a decisive influence on all the more recent attempts at a new classification of the Sternoxi, but it has at the same time weighed heavily against the probability of finding in the study of the larvæ a sure guide to the true classification of insects—a circumstance which Erichson has not omitted to mention in the introduction to his instructive treatise on the larvæ of Coleoptera (in Archiv f. Natur-

geschichte, 1841, i. p. 62). He admits that very much will be gained for the classification of insects by a more accurate knowledge of their earlier stages; but at the same time he warns us against entertaining too high expectations as if the progress of classification principally depended on the study of the metamorphoses, and he urges particularly that we must not suppose that a classification according to the larvæ would always coincide with a classification according to imagos. He mentions by way of illustration that one would naturally expect a great similarity between the larvæ of Buprestidæ and those of Elateridæ, which does not really exist, and that the larva of *Melasis* would make a nearer approach to the *Elater*-type than to the *Buprestis*-type, whereas the reverse is rather the case. A couple of pages further on he sums up his remarks in this general result—that, although it would not be possible to build a classification on the structure of the larvæ, it will nevertheless be of the greatest importance, nay, decidedly necessary, to take that point into consideration, as it will always do good service as a means of testing classifications founded on other principles,—a general statement which I have no doubt sounds so very qualified principally because he was checked by the idea that Buprestidæ and Elateridæ are very nearly allied to one another, though their larvæ are so different, and by the apparently anomalous relations of the larva of *Melasis*. But for these points being present to his mind, his verdict would have been much fuller and more decided. These words, like so many others which have proceeded from the celebrated entomologist—too early taken away from his bright scientific career—have awakened an echo in many a dark corner, and since served as a principal support for the often repeated and convenient assertion that the earlier stages of insects correspond in many cases so little to the relationships of the imagos, that they even at times vary more according to species than generally according to genera or families. And thus it has come about that this view of the larva of *Melasis* now stands as a sort of barrier in front of an immense tract of scientific fallow land, which only by the razing of that barrier can be made available for new culture.

And this barrier indeed seems indestructible; for how could anybody presume to doubt that the larva of *Melasis*, which presents such a striking external similarity to the typical larva of *Buprestes*, also burrows in timber like the latter, seeing that we possess minute accounts of it by such able entomologists as Nördlinger* and Perris†, the former of these having, as well as Guérin‡, even supplied us with drawings of its burrows, galle-

* Stettin. entom. Zeit. (1848) pp. 225–226, t. 1. fig. 2.

† Ann. de la Soc. Entom. de Fr. sér. 2. v. 548. ‡ *Ibid.* i. pl. 5. fig. 4.

ries, and beds for the pupa excavated in the solid timber? At first sight an attack seems hopeless on so strong a scientific fortress; but a closer inspection will, I trust, discover more than one weak point.

The structure of the larvæ of Buprestidæ is easily understood, for in every point it exhibits with great consistency the peculiar characteristics of an animal burrowing in wood. Such are the large head deeply seated in the prothorax, the short thick mandibles formed like a hollow chisel, the large protruding labrum, the short, freely developed lower organs of the mouth, the powerful muscles of the neck, the broad prothorax beset with grains of chitine, the slender body adapted for creeping through galleries, the large anal segment, which is turned straight backwards. If now the habits of the larva of *Melasis* are really the same as those of the larva of Buprestidæ, its structure must be identical with theirs at least in these principal points. But if the similarity only applies to the external structure, it is clearly insufficient, however striking, to prove a true *affinity* between these creatures, or even a similar way of feeding; it merely justifies us in supposing that they live in similar localities and use a similar mode of locomotion. One would think that such a conclusion, of which the truth is evident to common sense at every step in the study of living creatures, could not but be sufficiently appreciated and generally adopted. Nevertheless, as I have often urged on other occasions, no principle is oftener sinned against. No source of errors in natural history flows more copiously than that which rises from the confusion of relationship with similarity, of affinity with analogy, of typical characteristics with biological modification; so that it is but too clear that we have as yet advanced but very little towards the great aim of comprehending the rational consistency of nature. It is this ancient, ever recurring mistake which also in this case has obscured the truth.

For in spite of the positive and decisive appearance of the investigations just alluded to, they nevertheless embody a simple impossibility. Instead of a rasp-like chitinous armour on the prothorax, the larva of *Melasis* has merely a couple of narrow, partly transversely grooved bands of chitine, and its skin is generally thin and weak; the lower organs of the mouth are rudimentary, and coalesce into a small plate; the labrum is absent; the mandibles are pointed and bent *outwards*, they have a tooth *on their back*, and their inner margin presents merely a narrow unarmed edge; the head is free, rather soft, with only a few firmer bands of chitine forming a framework round the epistoma and hypostoma; the anal or tenth abdominal segment, which in the larva of Buprestidæ forms a direct continuation of the body, appears here merely as a small

protuberance on the ventral surface of the ninth segment; this latter exhibits exactly the same serrated margin as in the larva of Elateridæ—a circumstance which has hitherto been entirely overlooked, perhaps because it is very little chitinized in *Melasis*; and, finally, the larva of *Melasis* has no buccal cavity at all, but only a very small opening for the mouth, so small that it can only be observed with difficulty—a point hitherto overlooked, but of the greatest importance.

As soon as these facts are fully appreciated and properly combined, every idea of an animal so constructed burrowing in timber and feeding on it must at once be relinquished; and if we then examine the accounts before us, it will soon appear that the investigators have not really seen what they and others think they have seen.

Guérin had the larva and the piece of wood he figures sent to him from the Vicomte de Lamotte-Baracé, and he therefore founds his statements entirely on the written account of an unscientific correspondent.

Professor Nördlinger found the beetle sitting on an alder branch 3 inches in diameter and perforated with galleries in all directions. He asserts that “the deposition of the eggs certainly takes place in the same way as in Buprestidæ, the mother beetle therein making use of clefts in the bark or even in the timber;” but as he does not say that he really has observed the process, his assertion, in spite of its decided language, cannot be looked upon as anything more than a mere supposition. He states, on the other hand, that he did find a dead beetle with its head and body half hidden in a “fly-hole”—that is, one of the openings made by perfect insects on making their escape, at the end of their transformation, from the timber on which they lived as larvæ; but he surmises that it only intended to hide itself there; for he says, if the beetle had penetrated into the timber through old burrows and deposited its eggs in the galleries, he thinks that he must have met with beetles in such burrows, which he has not. He adds, however, one observation which admits of no other explanation than that the eggs had *not* been deposited from the outside on the bark, but, on the contrary, in a burrow inside the wood—namely, that he found quite young larvæ in the thick of the timber, several inches from the bark. From a log of wood taken in one year, in November, beetles made their appearance through several consecutive years, from which he considers that the larva takes at least three years to complete its development. The larva is found in the burrows in a bent-up position, compressing the wood-dust behind itself so as to form an arched cavity. The burrows are undulating, but only in a horizontal plane*.

* Stettin. entomol. Zeit. (1848) p. 225–226.

According to Perris, this larva forms broad irregular galleries in the interior of the timber, at a depth of from 2 to 5 centimetres. The form of these galleries is, in his opinion, as characteristic as that of the larva itself, being different from the burrows of any of the many other timber-larvæ with which he is acquainted. He states that the walls are so smooth that they look as if they were produced by means of a very sharp instrument*; and as this is indeed the only remarkable peculiarity which he mentions in these burrows, it would appear as if he looked upon this smoothness and evenness as their great distinctive feature. But such are the burrows of a great many, if not all, timber-larvæ, when they are cleared of wood-dust, which, generally speaking, is indicative of their being *old* and long left by their original inhabitants. There is therefore nothing really characteristic in this; and I am inclined to think that Perris's expressions rather proceeded from some indistinct feeling that the appearance of the burrows did not quite agree with that of the larvæ (supposing the latter to have constructed them). For just before, speaking of the outward-bent hooked form of the mandibles, he says that he should have thought it a monstrosity if he had not found it in all the individuals he examined and thus convinced himself of its being of constant occurrence. He adds the observation that the larva moves its mandibles horizontally, like other larvæ, but that it gnaws the wood *not in closing them, but in opening them*†.

Here, then, we are placed face to face with the unheard-of phenomenon that the mandibles of an articulated animal bite and gnaw, not by being approached to one another, but by being separated, not by closing, but by opening, not by the action of their flexors, but by that of their extensors! We are called upon to believe that a larva not only makes way for itself through solid timber, but even constructs extensive burrows and galleries with extremely smooth walls, lying all the while quite loose curled up on its side without support, working in a desultory

* "Elle s'enfonce dans le bois à une profondeur de 2 à 5 centimètres, en creusant des galeries larges et irrégulières dont la forme est aussi caractéristique que celle de la larve même et comme n'en pratique aucune des nombreuses larves xylophages que je connais. Ce sont des cavités qui ont en largeur une fois et demi celle de la tête, et près de trois fois celle du corps et guère plus d'un millimètre de hauteur. Leurs parois sont si nettement taillées qu'on les dirait façonnées par un instrument très-tranchant." (Ann. de la Soc. Ent. de Fr. 2^e sér. v. p. 545.)

† "Je crus la première fois, que c'était une erreur de la nature, une sorte de monstruosité, et si je n'avais vu qu'une seule larve, j'aurais certainement signalé avec quelque méfiance une semblable anomalie..... Le jeu de ces mandibules est horizontal comme dans les autres larves; mais c'est en s'écartant et non en se rapprochant qu'elles rongent le bois." (L. c. p. 543.)

manner, spreading out a pair of pointed hooks now in one direction and then in another !

Nevertheless it is but justice to these observers to say that, had they not gone to their task with their eyes blinded by prejudice, they would not have imagined they saw what they never really did see, nor have taken refuge in interpretations which they would otherwise have disdained; and their prejudice was, that similarity in outward appearance always entails similarity in habits of life. Whether the mother beetle deposits her eggs in the clefts of the bark, or, what is far more probable, penetrates through the openings of old burrows, and lays her eggs in old galleries, these latter are certainly not the work of the *Melasis*-larva.

The similarity in outward appearance between this larva and those of Buprestidæ means nothing more than that the former is destined to live in the burrows formed by the latter or by other similarly equipped xylophagous larvæ. What the larva of *Melasis* tears and perforates with its mandibles must be something soft, not a hard substance; in fact it cannot be anything else than the skin of really xylophagous larvæ and pupæ. Whatever be its food, it must take it in by drinking, and there is nothing for it to drink but blood.

IV.

A minute orifice of the mouth; pointed mandibles, placed at a distance from the mouth; no labrum; the lower organs of the mouth coalesced; short antennæ; slender body; the ninth abdominal segment serrated; the anal segment placed under the preceding; movement by lateral winding of the body: these were characteristics of the larva of *Melasis*, and these same characters are those of the larvæ of Elateridæ. Nor must we allow ourselves to doubt their affinity because the former is destitute of legs and of chitinous armour, or because the mandibles are bent outwards instead of inwards and the second and third pair of appendages of the mouth are rudimentary; to lay overmuch stress on these points would simply lead us through a byway back to the same confusion which has done so much mischief, and owing to which the *Melasis*-larva was thought more closely allied to the larvæ of Buprestidæ than to those of Elateridæ merely because it was apod and soft. The larva of *Melasis* does not in reality present a greater modification from the type of Buprestidæ than many of those which I have described in my Contributions to the Knowledge of the Larvæ of Coleoptera*—not more, for in-

* Naturhistorisk Tidsskrift, ser. 3. vol. i. pp. 193-232, pl. 3-10; vol. iii. pp. 131-224, pl. 1-12.

stance, than the remarkable larva of *Haliphus*, which in so striking a manner maintains the type of its family, whilst so widely differing in external appearance. At the same time, perhaps, there is not much reason to fear such an objection just at present; for although it is still constantly repeated that the larvæ of Elateridæ are generally phytophagous, and only exceptionally take animal food, I do not hesitate to assert directly the contrary—namely, that they are carnivorous as a rule, and only exceptionally phytophagous; and the positive affirmation of this truth has, so to say, long been looming in the horizon. Erichson considers the larvæ of Elateridæ unreservedly as phytophagous, some being supposed to feed on decaying wood, others on fresh roots: nevertheless he was not without scruples, for he adds, in a note, that he doubts whether larvæ with such a mouth really can masticate their food (*Archiv f. Naturgeschichte*, 1841, i. pp. 87–88). Nor do I doubt that many a collector, when his attention is drawn to the subject, will remember very often to have met with these larvæ under bark, in decaying wood and wood-dust, engaged in the very act of piercing the bodies of soft larvæ and pupæ, and thus be enabled to confirm from his own experience those testimonies which already have appeared at different times as to the carnivorous habits of the larvæ of Elateridæ. It seems that the attention of some has already been drawn to the analogy between the structure of their mouth and that of the larvæ of Carabi; so that it may soon be generally acknowledged, what I certainly hold to be the true view, that they are as truly typical carnivorous animals as the larvæ of Carabi, and that they bite through the skin of their prey, tear it to pieces, crush and suck it just like the larvæ of Carabi—with which tribe they also correspond in this particular, that a certain number of them, being on purpose endowed with shorter and thicker mandibles, shorter legs, less perfect armour of the point of the abdomen and of the anal segment (that is, with less power of locomotion), eat their way into juicy and farinaceous roots, destroying them in the same way as the animal food of the majority is treated, by crushing and sucking. It is a state of things quite analogous to what we find in insectivorous and carnivorous mammalia, among which the hedgehog, the badger, and the bear are distinguished by modifications of the type, either in the movements of the jaws, or in the teeth, or in both, which do not by any means destroy the original carnivorous type, but nevertheless enable the animal to extend its range of food to vegetable matter sufficiently rich in nitrogen.

If, now, we comprise within our view the whole division of Sternoxi, starting from this new information we find that the

larvæ of that division group themselves round two, and only two, entirely different types—that of *Buprestis* and that of *Elater*, the former burrowing in different parts of plants and being phytophagous, the latter being blood-suckers or living on vegetable juices. In both divisions we meet with modifications of the type analogous to those met with in all other natural divisions of Coleoptera,—their body being more or less hard or quite soft, the buccal organs, the organs of movement, the limbs, the point of the abdomen and the anal segment more or less developed—all in accordance with the occurrence and quality of the food. The larva of *Melasis* thus belongs to the *Elater*-type, but is modified for the purpose of hunting xylophagous larvæ living in hard wood. In the larva of *Fornax* the mouth appears, from the description of Coquerel (Ann. de la Soc. Ent. de Fr. sér. 3. iv. pp. 511–516, pl. 15. fig. 3 *j, l, m*), to be still more modified than that of *Melasis* in the direction of the organization met with in such larvæ of Antliata as live on prey in galleries in wood, *i. e.* in those larvæ of *Laphria* which suck the larvæ of Buprestidæ.

These larvæ of Antliata correspond, within their own order, exactly to the larvæ of *Melasis* and *Fornax* in Coleoptera, the relation in point of structure between the former and the phytophagous larvæ of Antliata being exactly the same as that between the Coleopterous larvæ in question and those of Buprestidæ. That Coquerel failed to discover the opening of the mouth in the larva of *Fornax* can have been caused only by the fact that it merely possesses a small orifice for sucking blood, whereas he expected to find a large cavity of the mouth, supposing as he did that the larva burrowed in timber and fed on wood. Lacordaire, who also supposed that it “fed on wood” and constructed galleries, though only in decaying wood, is likewise astonished at the want of a mouth (Gen. des Coléopt. iv. p. 565).

I have on purpose limited the preceding inquiry into the larvæ of Buprestidæ and Elateridæ to what was absolutely necessary for the attainment of my aim, which was nothing more than to clear away the obstacles which that interpretation of their structure which has hitherto prevailed has placed in the way of that view of their mutual relationship which will be developed in the sequel. I am in possession of very rich materials for the illustration of these larvæ in detail; but I reserve that for the continuation of my papers on the larvæ of Coleoptera, published in the ‘Naturhistorisk Tidsskrift.’

V.

For a long time after the publication of Audouin’s well-known treatise on the thorax of Insects, in which he had distinguished

as a separate piece a small part of the skeleton situated near the root of the coxæ and called by him the *trochantin*, only very little attention was paid to it. The modern examinations of the external skeleton of insects, undertaken for the purpose of discovering useful marks of distinction for the numberless genera and other divisions established by entomologists according to a general impression of the habitus of the animals, have, however, in some cases led to the trochantins being taken into consideration; and they are said to exist in some cases, but to be wanting in others. This view, however, appears to be erroneous. They seem never to be wanting in Coleoptera (to which we are now particularly alluding), although they vary very much in size and shape; and the difference in question would be more correctly indicated by describing the trochantins as either covered by a prolongation of those plates of the skeleton which surround the coxæ, or uncovered and bare. At the same time, however, cases would occur in which it might be difficult to say whether the trochantins should be called covered or uncovered, as in some instances they are not visible till the coxæ are turned back in their sockets. Besides this, the definition of the family of Buprestidæ now generally adopted contains another still more misleading feature—that part of their thorax which has been called the trochantin being an entirely different piece and having nothing to do with the coxa. In one instance the common interpretation has been exchanged for a new one; but this new interpretation is not only erroneous in itself, but does not agree with a thorough understanding of the true structure of the prothorax in insects.

In Buprestidæ, as well as in Elateridæ, each of the anterior coxæ is on the outside surrounded partly by a receding prolongation of the prosternum, and partly by a portion of the lower edge of the epimeron. In the first group of the family of Elateridæ (see my classification below) these lateral laps of the prosternum are very short; but in the second group of Elateridæ and in Buprestidæ they are so long that they occupy about the same space as the epimera on the outer margin of the coxa. In all Elateridæ the laps of the prosternum and the epimera join so closely that the upper and outer part of the coxæ, and with it the trochantin, are entirely hidden; whilst in Buprestidæ the parts in question do not join closely, whereby the socket of the coxa receives a small and narrow extension on the outside, and in this open groove a part of the coxa is always seen, whilst the little round trochantin itself is not seen, unless the coxa is turned back a little. It is therefore better to express the difference between these two families in this respect by drawing attention to the opening between the prosternum and epimera than by saying that the

trochantin is visible in Buprestidæ, hidden in Elateridæ. But if we say, as authors usually have said hitherto*, that only Buprestidæ possess trochantins, which are wanting in Elateridæ, then the real fact is entirely missed. And if other authors, as Lacordaire and Thomson, go further, and state that the trochantins are very large and prominent in Buprestidæ, and put this forward as one of their principal characters, then they must have overlooked the real trochantins, which are very far from being large or prominent, whilst the lateral prolongations of the prosternum just mentioned have been mistaken for trochantins. Nor is this mistake inexplicable; for the laps in question are in Buprestidæ separated from the rest of the prosternum by a more or less deep groove, whereby they assume the appearance of being connected with the coxæ. But any such belief is at once dispelled by turning the coxa about, in fresh or softened specimens, when it will be seen that the supposed trochantin remains quietly in its place, instead of following the movements of the coxa as a real trochantin would; and if the coxa is turned back in the socket, the real trochantin will appear in the open groove. To render the experiment still more convincing, detach the coxa from its socket, and the true trochantin will be found sitting in its proper place, whilst the supposed trochantin shows itself to form one piece with the prosternum.

The only author who has refused to regard the lateral prolongations of the prosternum as trochantins is Von Kiesenwetter, who, without further explanation, describes them as episterna (Naturg. d. Insekten Deutsch. iv. p. 6). But, as already stated, this seems to imply another mistake. What we call epimera in the skeleton of Arthropoda are nothing but the chitinized side-folds (pleuræ) between the ventral and dorsal shields of the segments—that is to say, (in the thorax of insects) between the pro-, meso-, and metanotum above, and the pro-, meso-, and metasternum beneath. In many insects having the thorax strongly chitinized the epimera are found to be divided into two parts, of which the foremost is called the episternum, whilst the hindmost is then alone called the epimeron; but this division is owing merely to the necessity of procuring access for the air to the spiracles, which open behind the epimera. As, however, the articulation between the prothorax and mesothorax is so loose that the air can always easily penetrate into the spiracula prothoracica which are situated between them, there is no necessity for a division of the epimera prothoracica into episterna and epimera *sensu strictiori*; nor do we ever find such a division carried out,

* Lacordaire, Gen. des Coléop. iv. 1. pp. 90, 94, 130; Leconte, Classif. of the Coleopt. of N. Amer. i. pp. 156, 158, 159; Thomson, Skandinav. Coleopt. vi. pp. 6, 56.

although a slight indication of it may be found in some cases, where the posterior part of the epimeron is somewhat bent outwards. It is even very rare to find the pronotum and epimera prothoracica separated by a real suture (as in Carabidæ); nay, it often occurs that the sutures between the pronotum, prosternum, and the epimera become to such a degree effaced that the entire prothorax seems to consist of only one piece (as in most Curculionidæ). In Buprestidæ and Elateridæ all these parts are immoveably united, but the seams between the prosternum and epimera are always to be recognized, and the junction of the epimera and pronotum is marked by the more or less sharply raised lateral edges of the latter. It follows that the Buprestidæ possess no episterna on the prothorax, any more than any other insect, unless that appellation is to be given to the large lateral shields themselves which are commonly called epimera. Von Kiesenwetter regards the true epimera as laterally inflected parts of the pronotum, and gives the name of episterna to the prolongations of the prosternum (which other authors equally erroneously call trochantins), and thus he comes to the result that the prothorax in Buprestidæ consists of pronotum, episterna, and prosternum, but in Elateridæ of pronotum and prosternum alone (Nat. Ins. Deutl. iv. p. 217), whereas the prothorax in both families consists of the same pieces as in other insects, viz. pronotum, prosternum, and epimera prothoracica, as shown before.

VI.

Anybody who has watched nature a little in field and forest knows full well that faculty in the *Elateres* which has procured them the popular name of spring-beetles. It would therefore be natural to expect that the peculiar contrivance by means of which these beetles are enabled, when placed on their back, to toss themselves up in the air and fall down on their legs, had long ago been so thoroughly investigated and understood by scientific entomologists that it could always with certainty be decided whether any given species is endowed with this faculty or not. But this is very far from being the case: it is still a moot point with regard to many animals of the *Elater*-type whether they can spring or not, so that, generally speaking, one is not satisfied till one has seen the thing done before one's own eyes; and with regard to this mechanism there is but little agreement amongst entomologists, except concerning the cases where the articulation of the prothorax and mesothorax is sufficiently loose to allow us to inspect easily the whole structure and proceeding. This latter has been familiar for a very long time; and short and correct accounts of it are given in old manuals, as by Latreille in Cuvier's 'Règne Animal.' It is true that some

German naturalists (particularly Burmeister and Erichson), whose statements Lacordaire in this as in most cases implicitly adopts, have tried to overthrow these simple results of experience by means of utterly erroneous theories; but another German author, Von Kiesenwetter, has again returned to the true track, and given a correct and lucid description (Nat. Ins. Deutschl. vi. pp. 224–226). This, then, may be considered sufficiently well established,—that if a *bonâ-fide* “skip-jack” finds himself lying on his back, he at once folds up his legs and antennæ, pressing them closely to the body, so that as little of them as possible protrudes; he then pushes back the prothorax so far that the point of the prosternal spine meets the salient middle part of the mesosternum, for which purpose it becomes necessary to bend the body in, so as to form an obtuse angle; the animal then begins to contract the flexors of the prothorax with constantly increasing force against the point of support on the mesosternum which has thus been obtained: suddenly it lets go; the prosternal spine glides rapidly along the groove in the mesosternum and down in the dip which is adapted to receive it; the most prominent parts on the dorsal surface of the animal, particularly the bases of the elytra, are thereby violently struck against the ground, and, by the recoil, the whole body of the animal is tossed up into the air: while in the air, it unfolds its legs, in order to be able to catch a hold with its claws if it comes down on its legs. It is apparent that a very free articulation between the prothorax and mesothorax is necessary for this operation; and accordingly we find both the pronotum and the bases of the elytra steeply inclined towards the articulation; it is further apparent that the prosternal spine, the prolonged mesosternum, with its little dip in front, its sliding plane, and the deep excavation at its root, play a principal part; and from this starting-point a great many conclusions may be safely made. It is evident why the skeleton of the spring-beetle is so hard—because otherwise it would not possess the requisite elasticity to effect a sufficiently strong recoil from the ground; we perceive why the whole shape is moderately long and narrow, with rounded points in front and behind, closely fitting edges, and elliptical outline both in the longitudinal and cross sections, why all the limbs are more or less completely adapted for being received into grooves on the lower surface of the head, sternum, and abdomen, the legs for being folded up, the hip receiving the femur, this again the tibia, and the tibia in its turn receiving the foot; finally, we see the necessity of the prothorax being long and shaped like a cushion above and below, far thicker than the exigencies of the muscles of the neck and legs would require. It is clear that in the same proportion as these arrangements

are more complete, more carefully adjusted and balanced, the greater is the power and accuracy with which the animal exercises its springing faculty, and the more often can it repeat it; in the same degree as the skeleton is harder and more naked, the prothorax longer (whereby the clicking-joint is placed more in the middle), its hind quarters longer and more pointed, the joint between the elytron and pronotum more free, the root of the elytra thicker and their ribs higher, the more perfect is the performance of the clicker.

We possess even in our native species a more than sufficiently rich series of exemplifications of all these and many more modifications of the different parts composing this machinery, which are combined in infinitely varied ways.

But if it be so (and after all that has been said I do not suppose that anybody will doubt it), that this "clicker-business" really is the fundamental peculiarity in the *Elater*-type, why, then, is it that entomologists refuse to admit into the family of Elateridæ a numerous series of beetles (such as Throscidæ, Melasidæ, Eucnemidæ, Cebionidæ) in which the selfsame structure recurs in all its essential points, but which are not considered true, genuine, and *bond fide* clickers? What is the difference? If the question is put in this straightforward manner, the answer is not difficult. The fact is evidently this, that the springing-apparatus has not yet been so thoroughly studied that the type of it can be recognized with certainty in the cases where it is not carried out to its fullest perfection. Only thus can it have happened that this feature of the structure is so far from having been brought forward as an essential and fundamental character, that, on the contrary, it has been given up in despair, as "leading to entirely illusory characters" (Lacordaire, Gen. d. Coléopt. iv. 1. p. 131), and unfit to distinguish the family of Elateridæ either from the intermediate divisions just mentioned, or even from Buprestidæ. But if this at present is the whole upshot and result of scientific inquiry in the matter, it is quite clear that neither Elateridæ nor Buprestidæ are really understood. That they are nevertheless constantly placed side by side in the systems is therefore owing merely to the similarity of their external habitus; and then the loss of that mark of distinction, which was shown to be valueless in the preceding part of this paper, will be severely felt. The great question which still is unanswered, and which we shall next attempt to solve, is this:—Does the similarity in shape of Elateridæ and Buprestidæ signify one and the same thing, express one and the same type? Only when this is answered can we hope to be liberated from the spell of illusion.

Let us then, first of all, on some *Buprestis* lift the prosternal

spine out of its bed on the mesosternum, and we shall then find that this bed is shaped so as to fit the spine exactly, so that there is nothing different in the arrangement from what we find, for instance, in Carabi and in Dytisci; that is to say, it has no other object than to procure a firm junction between the parts. And this same tendency to firmness, and even rigidity, is not confined to this point, but is carried out in the whole structure, by every means which the elements of the body offer, along the whole ventral surface—that is to say, in that line which in Arthropoda corresponds to the spinal column of Vertebrata. We observe, first, the peculiarity that not only the mesosternum and episterna mesothoracica, *but also the epimera mesothoracica*, take part in the articulation with the prothorax; secondly, the complete coalescence of the ventral segments, save the last three; finally, that the abdomen prolongs itself with a very strong spine or wedge between the posterior coxæ, reaching the metasternum, embracing also the posterior coxæ laterally by means of two large lobes, which reach the epimera metathoracica. In most Buprestidæ there is this further provision, that the pronotum, by a backward prolongation, wedges itself in between the elytra. Whilst now in Carabi the firmness and compactness of the body is required to render them fast runners, in Dytisci to increase their power of swimming, its significance in Buprestidæ is to render their flight strong. They are the Colibris amongst beetles, creatures fitted for living in strong sunlight, with markedly sculptured surface, sparingly endowed with hairs, rich in glittering metallic colours, resplendent with green, gold, purple, and azure—with a broad metathorax for the powerful muscles of the wings—of ovoid figure, pointed behind, with the centre of gravity between the wings, which are without cross folds (unique amongst Coleoptera), so that they can be unfolded for flight with lightning speed—with large oval eyes, presenting numerous fine facets, calculated for broad daylight—short naked antennæ, with spots of pores—short folding legs which, though not of very characteristic form, pointedly retain their character of walking legs, being of very nearly equal length, the trochanters of the posterior pair not supporting—the feet also, by their broad soles and membranaceous pads, announcing themselves as the representative of the herbivorous type of insect foot within the series of Serricornia*. Looking to their internal structure, we find that their tracheal system is extremely rich in air-vesicles—a peculiarity which does not seem to reappear amongst Coleoptera, except in Scarabæi, which, next to the Buprestidæ, contain the most powerful fliers of the order.

* Ann. & Mag. Nat. Hist. ser. 3. vol. xv. pp. 182–183, “On the Classification of Cerambyces.”

Then let us take some species or other (it does not matter which) of the divisions of Throscidæ, Melasidæ, Eucnemidæ, Elateridæ, or Cembrionidæ, and let us lift the prosternal spine out of its bed on the mesothorax, and we shall find that the bed is not by any means constructed only with regard to that spine; so that the arrangement is entirely different from that of the Buprestidæ. The place in which the prosternal spine rests always terminates behind in a deep excavation, which would be as superfluous for the accommodation of that spine as it is necessary for the accommodation of the "springing-spine" (*muco saltatorius*), the essential instrument of the springing beetle, which has hitherto been either overlooked or misunderstood, having been confounded with the prosternal spine. The fact is, that when the articulation of the prothorax with the mesothorax is not very free (that is, in most cases), the springing-spine is, on account of the limited space, placed on the upper surface of the prosternal spine, forming an angle with it, and therefore hidden by this when the animal is viewed from below. It is only when drawn out by the animal for use in springing, or when the prothorax is entirely loosened, that it is seen. By degrees, as the articulation of the prothorax with the mesothorax is freer, and the mesothorax more salient, the springing-spine assumes a more horizontal direction, and appears behind the posterior extremity of the prosternal spine; the boundary between the two is in this case marked by a small tooth, which is nothing but the extremity of the prosternal spine. Finally, in those Elaters where the joint in question is entirely free and open below, this little tooth also disappears, and with it the last indication of the original position of the springing-spine, which in this last case appears simply as the continuation of the prosternal spine.

We shall do well to pause a few moments after having gained these results. We have seen that the larvæ of Sternoxi group themselves round two distinct types, and we now see this bifurcation confirmed in the perfect animals by equally decisive and thorough-going marks of distinction. We found the type of the Buprestidæ to be that of an animal organized for flight, that of the Elateridæ to be characterized by the springing-mechanism. But the latter type is less one-sided than the former. The *Buprestis*-larva and its congeners are always xylophagous, burrowing in timber, and there is consequently not much room for variety in shape; whether the egg is deposited in clefts of the bark of trees, in the tenderer stem of herbs and shrubs, or in the parenchyma of leaves, the demands which the propagation of the species makes upon the structure of the beetle remain upon the whole the same; but time and strength will at the same time be to such a

degree engrossed by this part of its activity that the beetle's own nutritive life cannot be expected to express itself very strongly in its structure. The Elateridæ, on the contrary, are, as larvæ, carnivorous; and consequently we find amongst them a great variety of forms, according to the mode of life of the prey; and the corresponding demands for the equipment of the perfect beetle with regard to propagation causes a far richer variety of form among the Elateridæ than among the Buprestidæ. In those Elateridæ which, as larvæ, hunt their prey in closed galleries in timber, the faculty of springing is reduced in power and facility, whilst that of flying is more developed, and the animal then approaches somewhat to Buprestidæ in outer form, sculpture, &c.,—thus, particularly, in Melasini and Eucnemidini, especially in exotic genera, as *Pterotarsus*. Those Elateridæ, on the contrary, which, in the larval state, seek their food in less circumscribed localities are more developed as “clickers” than for flying, and therefore occupy a place in every respect opposite that of the others: excellent instances of this combination are afforded by many species of the group *Diacanthus* and congeners. The majority of Elateridæ stand between these two extremes, inclining sometimes more to one than the other. Elateridæ are consequently to a certain extent placed under equal conditions with true carnivorous beetles—that is, such as live on animal food in all stages of their existence; and it is therefore natural to expect further analogies with such beetles—as, for instance, with Carabidæ. Accordingly we find that they live in shade, or are mostly active at night, with close, fine, and minute sculpture, regularly ribbed (striated) elytra covered with short and fine hair; their colours are mostly dark and dull, principally black, brown, or ferruginous; some are more vividly coloured, red, or with chequered light and dark designs, or even with metallic lustre; but they rarely attain and never surpass that degree of splendour and lustre which is met with amongst Carabidæ. Elateridæ possess similar round eyes, and longer antennæ; and though the legs, for the sake of the springing-faculty, cannot be very strongly developed, they nevertheless retain the character of running-legs by the trochanters of the third pair being large and “supporting,” as in Carabidæ*. Nor is the analogy with Carabidæ deficient in this point—that amongst Elateridæ one group (viz. Cebrionini) is calculated for digging in the ground, just as several genera amongst Carabidæ. It is, however, time to turn our attention to the structure of the mouth.

* Latreille has already pointed this out in the *Elatères* properly so-called: “Femora postica ad basin appendice trochanteriformi instructa” (Gen. Crust. et Ins. i. 2. p. 248).

VII.

With regard to that series of families into which the division Sternoxi has been resolved, the constant verdict of modern authors is to the effect that the organs of the mouth are destitute of systematic value, and upon the whole are much reduced, which seems to mean that they are rather short and do not project much from the mouth (Lacordaire, Gen. des Coléopt. iv. 21. pp. 95, 96, 131). The same assertion is often made also with regard to other groups. Such a view, however, when properly considered, is always found to be erroneous; for if the structure of the mouth really remains the same in an extensive series of animals, this fact is not valueless, but, on the contrary, affords a never-failing indication of their near relationship. I say "never-failing," for in no case has it ever been found at variance with the testimony of the rest of the structure. If, then, the result of the investigation of the mouth is thought unsatisfactory, the fault lies in the preconceived views of the observer who rejects its testimony. It is the method of so many modern authors which leads to results inconsistent with nature; and if they find that the structure of the mouth is at variance with these results, it is said to be without systematic value, instead of that circumstance being accepted as a proof that the results obtained are erroneous. Authors are bent on distinguishing, and hunt after marks of distinction—for what? For those groups and divisions which are constantly being proposed on the strength of mere external and often accidental similarity in shape. Of course, the careful examination of every part of the animal accessible to the pocket magnifier, which constitutes the method of so many even of the best modern entomologists, does occasionally lead to the discovery of good and useful characters for classification; but such a method has really only a limited claim to the name of natural method which it assumes. It approaches the natural system in many points, but it attains merely a superficial contact; it never penetrates the essence of the natural system. Much material is sifted and laid in store by that method; but the scientific edifice of a natural system makes no progress. Not even the mere elementary task of procuring a survey of the material can be mastered by that method: the enormously complicated animal composition is much too intricate to be overcome by artificial classification; it must be realized in thought and imagination in its unity and through all its ramifications.

In order to appreciate properly the organs of the mouth, they, as well as other animal instruments, must be regarded both in their own mutual relation and in their relation to all the other parts of the organism. In Buprestidæ their develop-

ment depends partly on the nutritive side of the animal's life, partly on the requirements of propagation; but the latter predominate. The mandibles present the appearance of short, exceedingly strong, quadrangular, pointed, hollow chisels, with sharp or somewhat serrated edges, with a deep and roomy socket above, and a very prominent globular condyle below, which strongly reminds us of the head of the human femur. Their muscles are so large as to necessitate a very large and round skull. The mandibles are principally in the service of the propagation of the species, since it is by their means that the beetle, after its transformation, works its way out of the timber; nor is it improbable that they are employed in making preparations for the deposition of the eggs, viz. by facilitating the application of the ovipositor to suitable parts of the bark. They are largest in those Buprestidæ which, as larvæ, burrow deepest, and the food of the beetles consists in that case of leaves and buds*. In the group of Anthaxini, on the contrary, they are somewhat less developed; they are flatter, their extremities lacinated, and their inner margin less deeply excavated: in this case the beetle feeds upon pollen, and possesses peculiar bag-shaped extensions on the œsophagus for the preliminary collection and softening of this kind of food. The maxillæ are broad and powerful, their lobes small, coriaceous, covered with very stiff, short hairs—the outer one broader, but the inner one more pointed, than in the leaf-eaters. The mentum affords, by its clumsy shape and considerable thickness, a good support from below for the play of the mandibles and the maxillæ. The lingua is without stipes, small, thick, coriaceous, undivided, armed in the same way as the lobes of the maxillæ; the labial palpi are short, with much-reduced basal joints, but with free protrusible stipites. The palparium in both pairs of palpi is large (the terminal joint truncate) in those Buprestidæ which have to choose timber for their young; but it is small (the terminal joint obovate) in those which place their eggs in thin branches, stems, and parenchyma.

The great variety of forms amongst Elateridæ is expressed also in the structure of the mouth. Of this we meet with two types, one being principally calculated to serve the nutritive life, the other to serve the propagation of the species.

* According to information from Tranquebar, the large *Sternocera chrysis* swarms round certain trees, eating their leaves, as the cockchafer with us. In some years it occurs in great numbers. Once it happened that a box received from that locality contained nothing but hundreds of bellies of this Buprestid. The native who had been sent out collecting had understood the matter in his own way, and taken off the shiny green shields, which his countrywomen use for ornaments.

The first type is met with in those Elateridæ of which the larvæ hunt in the fields, under leaves and moss, in meadows or in decaying wood. The care of the offspring is here so slight that the beetle has time for running about to seek food for itself; and as this consists of pollen, the mouth resembles not a little that of those Cerambycidæ which feed on the same substance, particularly Lepturini. The labrum protrudes, covering the mouth from above. The mandibles are triangular, gradually pointed and arched, of no considerable strength, with small socket and condyle; the joint is cleft into two sharp teeth, one above the other; the whole inner margin is arched, and presents a sharp edge with a marginal fringe. The maxillary lobes are large, particularly the outer one; their skin is thin, and their edge covered by a close beard. The mentum is short and thin; the stipites of the labial palpi long, very moveable; the lingua large, broad, and bifid, with thin skin, and the margin closely fringed with hair, the stipes narrow and strong; the terminal joint of the palpi almost always subsecuriform, with a large palparium. This is the structure of the mouth in the group of Elaterini.

The other type, which is almost exclusively governed with regard to the propagation of the species, is met with in those Elateridæ which, as larvæ, hunt in more confined localities, particularly in galleries in wood. The care of the eggs, together with the considerable labour which may fall to their lot in order to get out of the timber, leaves very little time for the beetles to seek food for themselves; and according to the greater or less preponderance of these considerations, two modifications of this type are developed, of which one is analogous to that of Callidiini amongst Cerambycidæ, the other to that of Asemimi and Prionini in the same family.

The first of these modifications characterizes the group of Eucnemidini, and differs less considerably from the structure of Elaterini. The labrum is more or less obsolete. The mandibles are very powerful, and still furnished with an edge; but it is more or less clumsy and thick, and is without any fringe; the socket and condyle are large, the point sometimes entire, sometimes divided into two or more sharp teeth. The other two pairs of buccal organs are very small in proportion. Maxillary lobes and lingua considerably shortened, and rather to be described as covered with fine hair than as being provided with a marginal beard. The terminal joint of the palpi is of proportionally enormous size, broad, and securiform, with very large palparium.

In the second subtype, characteristic of the group Melasini, the labrum has entirely disappeared; the mandibles are of

enormous strength, with colossal socket and condyle; at the base they are so much extended both upwards and downwards that they appear as if they carried horns when seen from the back; their inner margin is destitute of fringe, excavated like a spoon, and the point sometimes whole, sometimes divided into several powerful and sharp teeth. The two other pairs of buccal organs are extremely small. The palpiferous stalk of the maxillæ is shaped like a joint, and stands out from the stipes; there is only one lobe, which is small, with thin skin and fine hair. The mentum is very small and thin; stipites palporum labialium not separate; lingua small, short, obtuse, undivided. The terminal joint of the palpi is very large, oviform.

It is a matter of course that both in Buprestidæ and Elateridæ the mouth is turned more downwards, in proportion as the beetle has more to do with wood, on account of the habits of the larva. The fore legs being, in both families, weak, with globular coxæ, the prothorax is naturally short, unless the elicking-apparatus be strongly developed, in which case also the organs of the mouth are larger, more protruding, and calculated for eating pollen. These, then, require protection during the work in earth, moss, and decaying wood, where the eggs are to be placed &c., which protection is afforded by a peculiar prolongation of the prosternum, a "chin-lobe" (*mentonnière*), by means of which the beetle can hide the organs of its mouth when the head is not protruded. Such a chin-lobe is therefore found in all Elaterini; but it is of varying size, more or less distinctly marked by a transverse groove, more or less turned downwards, according to the degree in which the Clicker-type is developed in the species. When authors deny (as Lacordaire does in *Gen. des Coléopt.* iv. p. 224) that such genera as *Campylus* and *Cebrio* possess this chin-lobe, and find one of their essential characters in this defect, this must arise from their not having sufficiently investigated the character of that organ, so that they are unable to recognize it when it is somewhat different in appearance from its most general form: For it must always be kept in view that this chin-lobe is merely a prolongation of the prosternum alone, which is indicated by its being separated, be it ever so short, from the epimeron on either side by a small sharp notch. Thus understood, the chin-lobe becomes one of the most essential characters of the group of Elaterini.

VIII.

On a former occasion I gave an account of the internal anatomy of Buprestidæ*, and I shall here offer a corresponding

* Oversigt over det Kongelige Danske Videnskabers Selskabs Forhandling (Transactions of the Royal Danish Society of Sciences), 1847, no. 3. pp. 24-35.

account of that of Elateridæ, only mentioning such details of the anatomical structure of Buprestidæ as will serve to clear up the differences between the two families. The statements I have to offer with regard to Elateridæ are the results partly of my own investigations of the anatomy of the insects, partly of a considerable number of dissections made by Dr. Fr. Meinert.

The tracheæ are without vesicles; the spiral ribs of the internal membrane of the larger trunks in the head and thorax are generally furnished with fine spines. The fat is not present in great quantity, though the less active species (as *Agriotes lineatus*, *obscurus*, *sputator*) have more of it; it is often of a yellowish colour, on account of the numerous yellow cytoblasts contained in the fat-cells.

True salivary glands are wanting, the cells secreting the saliva being not more numerous than can be accommodated in the walls of the pharynx, on either side of which a series of orifices give outlet to the ducts from these large and round glandular cells.

The digestive tube is of very simple construction, and so short that it never much exceeds the length of the animal, often only by a sixth or an eighth, more rarely by one-third. The pharynx is flat, strongly narrowed behind. The œsophagus is very short, gradually widened into the very small craw, which reaches a shorter or longer way into the prothorax. The muscular membrane of the œsophagus and the craw is rather weak; the inner membrane is covered with fine stiff hairs, which are directed forwards, more or less conspicuously arranged in longitudinal rows. The gizzard is very small, and in reality but little more than a pylorus formed by the narrowing of the craw, whereby the hair spines are made to stand closer together, so as to form a reversed wheel.

The stomach is cylindrical, straight, and reaches more or less far into the abdominal cavity; in front it is club-formed, distended, and the anterior end often protrudes so much that it receives the gizzard in a kind of dip. The muscular membrane of the stomach has in some cases equally well-developed longitudinal and transverse muscles, forming a net of quadrangular meshes, through which the layer of glandular cells peculiar to the stomach protrudes like warts; but in other cases the transverse muscles are weak, whilst the longitudinal ones are very powerful and strongly striated (as in *Lacon murinus*, *Diacanthus æneus*), through the intervals of which the cellular stratum protrudes as parallel longitudinal rows of small semiglobular cæca. The intestine is in the majority of cases straight, smooth, without prominent longitudinal bands or intestinal warts, mostly with unstriped transverse muscles, and without marked distinc-

tion between small intestine, large intestine, and rectum. But in *Cebrio* it is slightly winding, with powerful transverse muscles, the posterior half distended so as to form first a colon of considerable dimensions, in its posterior part furnished with many small cæca, and finally a short rectum, markedly separated from the former, and with powerful longitudinal muscles.

There are *four* rather short (in *Throscus* very short and thick) Malpighian vessels, of which the ends are closed and quite free, although each pair is closely held together by minute tracheæ. They consequently do not form two loops such as are represented by Léon Dufour (Ann. d. Sc. Nat. 1824, iii. pl. 2. figs. 3, 4).

Each of the testes consists of a bundle or tassel of shorter or longer folliculi, which are closely united by intertwined tracheæ and imbedded in fat, but not enclosed in a common bag. The testes are situated in the anterior portion of the abdominal cavity, close to the back, over the digestive tube, which runs close under them through the ring which is formed by the vasa deferentia. The number of follicles in each testis is very variable: in *Adrastus limbatus* there is only one, in *Cryptohypnus quadripustulatus* nine, in *Lacon murinus* more than twenty; but within the natural groups their number seems to depend principally on the size of the animals, so that it is upon the whole greater in the larger species and less in the smaller ones. Thus, whilst *Diacanthus æneus* has fifty, *D. tessellatus* forty, and *Agriotes lineatus* and *obscurus* fifty, *Agriotes sputator* has only twenty-four, *Ampedus balteatus* twenty, *Limoniinus minutus* nine to eleven; again, *Athous niger* has seventy, *A. ruficaudis* forty, and *A. subfuscus* twenty. All these numbers are approximate, as in each species the number vacillates between certain limits. In *Cebrio* the testes are distinguished by their extraordinary length and slenderness; they consist of more than 100 follicles placed on short stems in longitudinal rows, round the thin vas deferens, which occupies the middle.

The vasa deferentia are long, closely wound, and first extend a considerable way backward, passing the vesiculæ seminales, whereupon they bend forward again to the point where they join the ductus ejaculatorius. Near the testes they are slender, but increase by degrees in thickness, without, however, usually assuming very remarkable dimensions, except in species where they are very short (as in *Cryptohypnus quadripustulatus*, *Limoniinus minutus*, *Campylus linearis*); in species where they are very long they do not become very stout (as in *Ampedus sanguineus*, where they reach about 11·4 millims., in *Diacanthus æneus*, where they attain 19·2 millims., in *Athous ruficaudis*, where the length is about 11 millims.). In some species (for instance, *Agriotes aterrimus*, *Diacanthus tessellatus*, *Athous niger*, but not

A. ruficaudis) a short lateral branch starts from the point where they bend forwards again. In *Cebrio* the vasa deferentia, though very long, are towards their lower extremity suddenly extended into a long winding folliculus, of which the circumference is five or six times that of the thin part.

The ductus ejaculatorius is short, thick, and clumsy; it receives at the top, besides the vasa deferentia, three pairs of glandular vesicles.

The first pair of these, which are more properly described as vesiculæ seminales (spermatophorous glands), vary considerably in size and shape, though they form generally the most conspicuous parts of the interior sexual organs of the male. In *Diacanthus pectinicornis* they are fusiform, unusually small, 1.2 millim. long, whilst the ductus ejaculatorius in this species is particularly thick, club-shaped, and about 3.6 millims. long. In *Athous niger*, *ruficaudis*, and *subfuscus* they are, on the contrary, very large bags, of oval, on the inside somewhat concave form; in *Adrastus limbatus* and *Diacanthus tessellatus* the shape of the bag is still more arched and the inner anterior angles somewhat produced; in *Limonius minutus* and *Diacanthus bipustulatus* the curvature increases, and in the last-mentioned species the anterior angles are likewise produced; this protraction of the angles is further increased in another series of species, and the angles are variously wound, as in *Cryptohypnus quadripustulatus*, *Agriotes aterrimus* and *marginatus*, and *Ampedus balteatus*; in *Lacon murinus* the anterior angles are even divided each into two unequal branches, which are wound in spirals each in its own direction; in *Agriotes obscurus*, finally, the vesiculæ seminales have the shape of a stout, arched and winding tube, towards the end spiral, with a short, thick lateral branch, whilst in *Agriotes lineatus* they differ by being wound in double spirals at their end. In *Cebrio* these organs are slender, not stouter than the extended part of the vas deferens, with arched and spirally wound ends. But with regard to all these varieties of form, it must be observed that they embrace only the outer forms of the vesiculæ seminales, whilst the inner membrane is quite independent and does not by any means follow the external outline of the organ. This inner membrane forms a complicated system of cavities and expansions communicating with one another. In *Cryptohypnus quadripustulatus* its anterior part terminates in two long, extremely fine tubes, which accompany the anterior winding part of the vesicula. In *Agriotes obscurus* it forms a long tube with various dilatations, and is accompanied by a darker band, of alternating width, and of which the lighter parts show themselves to be composed of perpendicular cellular glands. The tube enters into the above-mentioned thick lateral

branch of the organ, runs through its whole length, and then doubles back and continues into the extreme end of the spirally wound part of the vesicula seminalis: from the point where it doubles back, near the extremity of the lateral branch, a long slender cæcum arises, of which the inner cavity soon becomes obsolete, and which then becomes exceedingly thin and pointed. The inner membrane is very firm and tough, and often pushes through the surrounding cellular stratum and the external membrane in the process of dissection under water.

The second pair of glandular follicles partly cover the vesiculæ seminales when the sexual organs are observed from below; they are generally cleft into two branches—one very thick and clumsy, behind the top of the ductus ejaculatorius, the other, which is more slender, in front of this (*Cryptohypnus quadripustulatus*, *Lacon murinus*, *Agriotes aterrimus* and *marginatus*, *Ampedus balteatus*, *Diacanthus tessellatus*). In other cases they are shaped like bags, the terminal part bent like a ram's horn (*Limonius minutus*, *Diacanthus bipustulatus*, *Athous vittatus*); or the terminal portion may besides be deeply bifid (*A. niger*) or be furnished at the base with a tubiform arched branch (*A. ruficaudis*, *Campylus linearis*). In *Adrastus limbatus* these follicles are dilated into the shape of balloons, and are very large, almost four times as large as the vesiculæ seminales; in *Cebrio* they are likewise very large, and the bags of elliptical shape.

The third pair of glandular follicles attached to the ductus ejaculatorius are almost always tubiform, of very varying stoutness and length: only in *Adrastus limbatus* have they the same considerable size and balloon-shape as the second pair of follicles possess.

The penis is narrow, spear-shaped, with a pair of narrow valves, which are generally furnished with a small tooth near their extreme point.

The ovaries are divided like the fingers of the hand. The number of fingers varies considerably, according to genera and species, but generally according to the same rule as that of the folliculi of the testes, so that the number is greater in the larger species, less in those of smaller size. Their number, however, does not generally exactly correspond with that of the folliculi testis, as may be seen by the following series of examples:—*Diacanthus æneus* has eighty to ninety fingers, *Athous niger* seventy to eighty, *Melanotus castanipes*, *Diacanthus pectinicornis*, *sjælandicus*, and *Athous ruficaudis* about fifty; *Lacon murinus*, *Agriotes aterrimus* about forty; *Diacanthus tessellatus*, *Limonius cylindricus*, *Athous vittatus*, *Campylus linearis* about thirty; *Cardiophorus asellus*, *Ampedus sanguineus*, *Diacanthus bipustulatus*, *Athous subfuscus* twenty to twenty-six; *Agriotes lineatus*, ob-

scurus, *sputator*, *Ampedus balteatus* fifteen to eighteen; *Cardiophorus ruficollis*, *Agriotes marginatus* twelve; *Cryptohypnus quadripustulatus* and *Adrastus limbatus* five. The oviducts are short, and open through a short common duct into the under surface of the vagina at a varying distance from its top; when filled with eggs, their appearance is quadrangular. The eggs are rather small, of short oval form: mature eggs, when taken out of the oviducts, measured in *Agriotes marginatus* 0·25 millim. in length, and 0·169 in width; in *Limoniæ cylindricus* 0·304 millim. by 0·179 millim.; in *Diacanthus bipustulatus* 0·309 millim. by 0·184 millim.; in *Diacanthus pectinicornis* 0·429 by 0·232 millim.

The vagina is either long and tubiform, or short and club-shaped. The tubiform type of vagina is, in places, of varying thickness, strongly curved (*Diacanthus pectinicornis*) or sharply bent at an angle (*Melanotus castanipes*, *Limoniæ cylindricus*, *Ampedus sanguineus*, *Diacanthus æneus*); when the oviducts join the vagina far behind the end of the latter, it is winding or even forms a spiral (*Lacon murinus*, *Agriotes marginatus*). The club-shaped vagina is not often gradually widened towards the fore end (*Adrastus limbatus*, *Agriotes lineatus*); more frequently the thick fore end is sharply defined, and besides is constructed so as to assume various forms (*Cardiophorus ruficollis*, *Cryptohypnus quadripustulatus*, *Agriotes aterrimus*, *obscurus*, *Diacanthus tessellatus*, *bipustulatus*, *Athous niger* and *subfuscus*). The internal surface of the vagina is furnished with a greater or smaller number of spinulose plates of chitine, or with spines placed in rows, or with both contrivances together, which do duty in the act of copulation as retaining instruments. The most frequent combination is a couple of lateral plates (*Cardiophorus ruficollis* and *asellus*, *Lacon murinus*, *Agriotes aterrimus*, *lineatus*, *obscurus*, *sputator*, *Diacanthus tessellatus*, *pectinicornis*, *sjælandicus*, *bipustulatus*, *Athous niger*, *ruficaudis*, and *subfuscus*). The plates are of different sizes, oblong, often with ribs and marginal teeth (*Athous niger* and *subfuscus*); and in some cases a second pair of plates over them are met with, which have spines on their inner margin (*Cardiophorus asellus*, *Diacanthus sjælandicus* and *tessellatus*); in *Lacon murinus* there are, besides the pair of plates first mentioned, a number of long spines at the anterior extremity of the vagina. When plates are wanting, the spines are so much the more abundant (*Agriotes marginatus*, *Ampedus sanguineus* and *præustus*, *Diacanthus æneus*).

The foremost dilated extremity of the vagina receives the semen during the act of copulation, and thus serves as a kind of bursa copulatrix, but is rarely separated by a constriction, which, however, is the case in *Cardiophorus ruficollis* and *asellus* and in *Campylus linearis*.

The spermathecæ likewise assume the form of dilatations of the anterior free extremity of the vagina. Their shapes are very various, sometimes that of a conic protuberance (*Cryptohypnus quadripustulatus*, *Diacanthus tessellatus* and *bipustulatus*), sometimes that of a tolerably long tube (*Agriotes aterrimus*), or of a short bag terminating in a tubiform continuation (*Melanotus castanipes*, *Limonius cylindricus*), or of two (*Diacanthus aneus*) or three (*D. pectinicornis*) short thick branches; in *D. sjælandicus* they are represented by five long tubes situated inside the vagina; in *Ampedus balteatus* there are two long club-shaped tubes proceeding from the top of the vagina, and five others starting from the duct of the accessory gland. This last case effects a transition to those cases where the tubes of the spermatheca do not open immediately into the vagina, but into its upper tubiform part, into the end of which the accessory gland opens, and which therefore may be looked upon as the duct of the latter. In *Cardiophorus ruficollis* this conduit is thin, towards the end wound and twisted, and bears on one side more than sixty short spermathecal tubes*. In *Agriotes marginatus* this duct carries close before its dilated end a long spermathecal tube, from which, again, a lateral appendix branches off towards its extremity. In *Agriotes obscurus*, *lineatus*, and *sputator* the duct is of extraordinary length, and near the base twisted in a double spiral, one outside the other; beyond this part, a very long twisted spermatheca separates itself from it, and beyond this, again, the duct carries a varying number of shorter club-shaped tubes along its sides; and, besides this, there is in *Agriotes obscurus* a short cylindrical tube, and in *A. lineatus* a somewhat larger deeply bifid bag, placed at the point of junction between the vagina and the duct of the accessory gland. In *Throscus*, finally, we find two small round spermathecæ, of which the ducts unite into a short common duct inserted near the base of the duct of the accessory gland; in their natural position they are placed upon the vagina like a pair of spectacles.

The accessory gland of the spermatheca in Elaterini is large

* The structure in *Cardiophorus asellus* is very similar; and there can consequently be no doubt that Stein (Anat. u. Physiol. d. Ins. tab. 5. fig. 1) has represented the sexual organs of this or an allied species of *Cardiophorus*—not, as he thinks, of *Athous hirtus (niger)*. To his account of the duct of the accessory gland, however, it should be added that the serrated form he represents is caused by the great number of lateral tubes (nearly forty), which do not join the duct at right angles, but lie along it slanting forwards. In Stein's drawing are also wanting the two elongated triangular plates of chitine (united at their ends) which are situated over the larger plates represented by him in the vagina; and, besides, the *seminal groove* is omitted, which here, as is usually the case, extends from the stem of the lateral follicle to the base of the common oviduct.

and shaped like a hand. The basal part increases in size with the number of the fingers; in *Diacanthus pectinicornis* it is divided into two or three lobes, with numerous short fingers. The number of these latter varies very much (in *Cardiophorus ruficollis* two, *Melanotus castanipes* three to five, *Diacanthus bipustulatus* five to six, *Campylus linearis* six to seven, *Diacanthus tessellatus* ten, *Athous subfuscus* thirteen, *Agriotes aterrimus*, *lineatus*, *Limonium cylindricus* twenty, *Athous niger* twenty to thirty). In *Lacon murinus* the fingers are ramified, with small triangular dilatations in the angles; the gland opens with a short stem in the side of the somewhat swollen and muscular end of the duct. In *Throscus*, on the contrary, the accessory gland is a simple, thick, but-little-wound tube, inserted at the base of the bursa copulatrix.

Several Elateridæ possess, besides, a pair of very large vaginal glands which have more or less thick walls, are closely united at their bases, and inserted above the oviducts in the receding angle between them and the vagina. This is the case in *Diacanthus sjælandicus* (but not in *D. pectinicornis*), in *Agriotes aterrimus*, *lineatus*, *obscurus*, *sputator*, and *marginatus*.

Many Elateridæ possess a peculiar, rather firm, inside more or less chitinized, funnel-shaped seminal groove, reaching from the base of the duct of the accessory gland to the mouth of the oviducts, or, in the cases where the vaginal glands just described occur, to their point of insertion—for instance, *Agriotes sputator* and *marginatus*, *Athous subfuscus*, and *Campylus linearis*.

Finally, many Elateridæ possess a peculiar kind of lubricating glands, of which the yellow oily secretion is destined to facilitate the sliding of the vagina in the muscular tube. In *Agriotes aterrimus*, *obscurus*, *sputator*, and *marginatus* they are oval, almost reniform; in *Diacanthus tessellatus* very long and slender, a little club-shaped toward their extremity. In *Melanotus castanipes* they are long, furnished with a lateral branch, and their end is tortuous; their walls are distinctly observed to be filled with transparent glandular cells placed edgewise; towards their mouth they are abruptly constricted, and then continue themselves as two minute tortuous tubes inside the outer membrane of the vagina, form a small dilatation, and finally perforate this membrane so as to discharge their contents in the muscular case of the vagina. The whole glandular tube can be moved by means of striped muscular fibres.

The ovipositor is a long, thin, chitinous tube, supported by a pair of small lateral flaps, terminating in a small joint covered with short and stiff hairs, which carries the vaginal palpi.

The male of *Lacon murinus* possesses a pair of bag-shaped scent-glands, of not inconsiderable dimensions; they are situ-

ated in the abdominal cavity, and can be pushed out behind the dorsal shield of the penultimate segment. When they are retracted in their natural position, numerous ducts, proceeding from the glandular cells (which are accumulated so as to form acini), are seen to open at their bottom. They are furnished with striped muscular fibres, fixed to the bottom and on one side, and when they are protruded, the greater part of the cellular tissue and muscular fibres follow the walls of the bags, and are consequently then situated inside the bags, which are turned outside in.

With regard to the nervous system, I have to observe that the ventral chords are not separated beyond the ganglion metathoracicum; but for the rest they are closely united, sometimes enclosed in one and the same neurilemma. There are eight abdominal ganglia, of which the first two are situated in the metathorax, the foremost of them close to the metathoracic ganglion; the seventh and eighth ganglia (the sexual ganglia) are as usual closely united. The nervous stems for the organs of respiration proceed as usual from particular small ganglia in front of the abdominal ganglia connected with the ventral cords.

If, now, we institute a comparison between the inner structure of Buprestidæ and that of Elateridæ, the essential results will be the following:—

BUPRESTIDÆ.

The *tracheæ* furnished with numerous vesicles.

Salivary glands very much ramified.

The *digestive tube* long, two or three times the length of the animal.

Œsophagus long, the craw large, situated in the hind part of the prothorax, in the mesothorax, or even in the metathorax:

Œsophagus with large lateral dilations in those species which feed on flowers.

The *stomach* long, with two horns on its anterior extremity, spirally wound behind, very glandulous.

The *intestine* bent at an angle, with strongly developed glandulous *colon*.

ELATERIDÆ.

The *tracheæ* without vesicles.

No *salivary glands*.

The *digestive tube* short, very little longer than the animal.

Œsophagus very short, the craw small, situated in the fore part of the prothorax.

Œsophagus simple, even in species feeding on flowers.

The *stomach* short, almost straight, without horns, very few glands.

The *intestine* straight; the *colon* not at all distinct, or, rather, indistinctly marked; few glands.

BUPRESTIDÆ.

Six *Malpighian vessels*, of which the ends are fixed to the angle of the intestine.

The *folliculi testium* very long, tubular, at the base elliptically dilated; the ends of all the folliculi in each testis twisted into a spiral; each testis furnished with its own enclosing membrane.

Two pairs of *vesiculæ seminales*,—one thick, pear-shaped; the other long, tubiform, closely twisted.

Spermatheca very simple, elongated, club-shaped, without accessory gland*.

The *ventral cords* of the nervous system separated in their entire length.

The ganglia of the mesothorax and metathorax coalesced.

Five *abdominal ganglia*; only the last three in the abdominal cavity. The first abdominal ganglion distinct from the metathoracic ganglion.

ELATERIDÆ.

Four *Malpighian vessels*, with free ends.

The *testes* free; the folliculi short, more or less round, mutually free.

Three pairs of *vesiculæ seminales*, of which two pairs vary exceedingly in structure.

Spermatheca of extremely varying, often very complicated structure, with large ramified accessory gland.

The *ventral cords* of the nervous system separated only as far as the metathoracic ganglion.

All thoracic ganglia separate.

Eight *abdominal ganglia*; the last six situated in the abdominal cavity. The first abdominal ganglion united with the metathoracic ganglion.

IX.

The investigations of which we have given the results in the preceding pages prove that the mutual relation of these two families is very different from what was formerly supposed. With regard to development, structure, and habits of life, they appear as widely separated as two families can be, within the boundaries of the same principal division of animals. Amongst Serricornia, Buprestidæ occupy, in all stages of life, the same place as Cerambycidæ and, more particularly, Lamiini (*Lamia*, *Saperda*, &c.) amongst the phytophagous or cryptopentamerous Coleoptera. Elateridæ, on the contrary, are carnivorous as larvæ, and in that stage of their life very like the larvæ of Carabidæ, from which it follows (on account of the influence of the generative life on the structure) that also in their perfect state Elateridæ

* In the paper above quoted on the anatomy of Buprestidæ, the bursa copulatrix is erroneously represented as spermatheca, and the true spermatheca as accessory gland—an error which was easily rectified by the use of a better microscope.

exhibit analogies with Carabidæ, as far as their larvæ live in a free state, but with Buprestidæ when their eggs are deposited in timber and for that reason are developed rather with a view to their flying-capacity than to their "clicking"-powers. On the other hand, their feeding on pollen causes analogy with the phytophagous Coleoptera, particularly with the Cerambycidæ, because analogous food requires an analogous arrangement of the mouth. The starting-point of the modifications of the mouth being thus identical in both families, we find a parallelism between these modifications in those cases in each family where the work of propagating the species becomes so considerable as to occupy the whole time and strength of the animal in its perfect state: thus Melasini and Eucnemidini amongst Elateridæ correspond to Prionini, Asemmini, and Callidiini amongst Cerambycidæ, just as those Elateridæ which frequent flowers correspond to Lep-
turini.

But if this be so, it seems that a new light is thrown on the whole series of Serricornia through these results. Very extensive investigations are necessary to place the relations of that entire division in a perfectly clear light, as our present knowledge of the great majority of these Coleoptera is entirely insufficient to afford us a deeper insight. But it may perhaps even now be predicted without presumption that the other divisions of that series likewise will show themselves parallel to different divisions in other series of the order of Coleoptera, the different elements of nutrition and propagation influencing the structure of the animals in a corresponding manner. The peculiar type of Coleoptera calculated for life in free air, which we describe as Serricornia, will most probably eventually divide itself into two principal series, each containing three or four families: in one of these series (distinguished by having four Malpighian vessels with free ends, and other characters) Elateridæ would correspond to Carabidæ, Cyphonidæ to Dytiscidæ, and Lampyridæ to Silphidæ and Staphylinidæ; whilst in the other series (distinguished by possessing, amongst other peculiarities, six Malpighian vessels, of which the ends are fixed to the intestine) Buprestidæ would correspond to Cerambycidæ, Anobiidæ to Curculionidæ, Melyridæ to Chrysomelidæ, and Cleridæ to Coccinellidæ.

Arguments derived from the general impression of the outward form, or from isolated considerations of some single feature in the structure or habits of the animals, would not avail against a comparison of this kind, which must be judged from those points of view which have been explained in the preceding parts of this article. Looking at the matter in this light, nobody can avoid being struck with the astonishing multiplicity

of combinations which the insect world exhibits also in this respect, seeing that in one single order at least four or five parallel series of great natural families can be pointed out, presenting so many cross combinations of characters in all their organic systems, always different in type, always analogous in modification, whilst the only other series of animals provided with true limbs, in the modern creation, viz. Vertebrata, hardly exhibits anything corresponding to this, except Marsupialia and Chondropterygii.

X.

It has been explained above how the Elateridæ, by degrees, as their habits of life associate them less with timber and wood, are less developed for flight and nocturnal life, and more for "clicking" and daylight life. The two extreme points of this development are indicated by *Melasis* and *Campylus*, which are connected by an infinite series of transitions; and *Campylus* approaches not a little to *Cantharis*.

The development of the *Elater*-type in the direction of flight and night life is characterized by the following features:—

1. The eyes become smoother, so that at last the facets protrude so little that they are not to be distinguished except when strongly magnified, and the whole cornea becomes quite shiny.

2. The sensitive pores of the antennæ* are more closely accumulated on the lower part of both sides of the joints, whereby well-defined poriferous spots are sometimes formed, usually from the third or fourth joint. Such spots, however, are not constantly distinguishable, except in *Melanotus*, *Adrastus*, *Agriotes*, *Sericosomus*, and *Ludius*. Amongst *Diacanthi*, *D. æneus* is distinguished by very small and little-depressed poriferous spots; and amongst the species of *Athous*, *A. rhombeus* is distinguished by double spots—namely, besides a lower series beginning on the third joint, also an upper series beginning on the fifth joint. The gigantic tropical species of the genera *Oxynopterus*, *Tetralobus*, and *Charitophyllus* possess extensive naked poriferous spots, particularly on the fan-branches of the male.

3. The forehead is more rounded downwards towards the mouth, the antennæ are more closely approached to one another, the prothorax is shortened, and the "springing-spine" (mucro saltatorius) is more distinctly separated from the prosternal spine; the legs are more completely arranged for being folded up and accommodated inside the margins of the body; the general outline of the body assumes a higher and at the same time more elongated oval shape, the edges are rounded off,

* See my treatise on Cerambycidæ, Ann. & Mag. Nat. Hist. ser. 3. vol. xv. p. 193.

the ventral surface more vaulted, the marginal ribs of the elytra effaced, their deflected lateral part (epipleura) is more bent in and diminished in size behind the coxæ; the legs are more arranged for running, with delicate feet and weak claws; the hairy covering becomes more close and silky, the sculpture less distinct, the ribs of the elytra lower, the colour duller, yellowish, brown, red, but never strongly metallic.

The development of the *Elater*-type in the opposite direction, towards springing and day life, is characterized by the following marks:—

1. The eyes become less smooth, the facets protrude more, and the appearance of the cornea becomes duller.

2. The sensitive pores are more equally spread over the whole surface of the antennæ.

3. The forehead slopes more gradually down towards the mouth; the antennæ are further removed from one another; the prothorax is more elongated, the mucro saltatorius presents a more direct continuation of the prosternal spine; the legs protrude more to the sides; the animal is less arched both above and below, the margins are sharpened, the whole outline becomes a more elongated ellipse; the marginal rib of the elytra becomes flatter and remains entire; the epipleura is more straight and broader; the legs are more especially adapted for walking and climbing, with club-shaped terminal tarsal joint and powerful claws; the body is more closely haired, the sculpture coarser; the ribs of the elytra are raised at the base; the colour is heightened often to metallic lustre, or to distinct design.

If every combination of characters drawn from this circle were used for the foundation of genera, we should reach that point towards which modern classification for a long time has been tending in this family as in others, viz. the identification in most cases of genus and species; for all these features unite in the most multifarious manner, constantly appearing in new cross combinations. In the following synoptical table of the Danish species these characters are therefore considered subordinate, and only used for the classification of species within the boundaries of the different genera. These latter are founded on other characters, which have been explained in all essential points in the preceding chapters, so that but little remains to be added here.

That *Sternoxi* exhibit similar differences in the composition of the sockets of the middle pair of coxæ to those observed in *Carabidæ* has been noticed in an earlier treatise*. Since then,

* Proc. Royal Soc. of Copenhag. 1855, p. 360. See Ann. & Mag. Nat. Hist. ser. 3. vol. x. pp. 377-379.

Thomson has shown with much ability the details of this point of structure in Elateridæ.

Throughout the whole series up to *Campylus* the ventral surface of the abdomen retains the same peculiarities, being horny, hard, arched, with sharp edges, and so composed that only the last segment is moveable—a circumstance which, even in dried specimens, is distinguishable by the fact that the membrane between the last two segments is bare. In *Campylus*, however, the ventral surface is flatter and softer, particularly along the side edges, where it is almost quite soft, and all the segments are moveable. This is in itself an indication of the power of clicking having in *Campylus* become a subordinate point, as in Melasini and Eucnemidini, though there it is due to a development of the type in an entirely opposite direction; for whilst in *Campylus* the faculty of springing yields the first place to the development of the legs, it is in the two groups just mentioned the power of flight which is increased at the cost of the “clicking.” But in *Campylus* we meet also with another important circumstance—namely, that the elytra do not, as in other genera of this family, fit into a groove on the pronotum, but protrude freely above its posterior edge. Amongst the digging Elateridæ or Cebriionini this arrangement is only met with in *Cebrio*. The preponderance which, in conformity with this, is accorded to the legs, shows itself in several peculiarities—for instance, in this, that the fore legs cannot, as in other Elateridæ, be accommodated inside the hind corners of the pronotum, which therefore are continued backwards in the form of a spout. These remarkable and important peculiarities in the structure of *Campylus* have hitherto been overlooked; and thus it has not only been classed together with such genera as *Hemiops* and *Plectrosterneus*, with which it has in reality nothing to do, but authors have even placed in the genus *Campylus* itself such species as *E. homalismus*, Illig., and others, which do not resemble *C. linearis* or *C. denticollis* in anything except in general outline and habitus, but entirely differ from them in the structure of the sternum, limbs, and abdomen, and therefore must find their proper places in other genera of Elateridæ.

Besides *Campylus* there is one other Danish genus of this family in which the pronotum is not arranged for receiving the base of the elytra in its hind margin, and in which, therefore, in like manner the springing-joint is without the essential support afforded by this articulation. *Campylus* shows by its whole structure that this want is connected with a reduction of the springing-faculty in all points, and an increased development of the limbs. We might therefore at first sight be surprised to find the same want of support in the articulation in a genus

including some of the most powerful springing beetles, namely *Cryptohypnus* (circumscribed in the manner indicated below). It is, however, clear that what is lost in firmness is gained in freedom of movement, inasmuch as the articulation thus modified allows the animal to stretch the prosternum much further back. We observe also that this bold feature in the structure of *Cryptohypnus* is combined with and compensated by the highest development of everything else which contributes to the springing-process, such as the long prothorax, elytra with raised ribs, &c., the small size (2 lines) of the animal being also an important element in this respect. No doubt this immense development of the springing-apparatus is calculated to suit the habits of the animal, because, living in sandy soil, they cannot depend either on firm support for the body in springing, or on a firm footing while running. In such localities these small "clickers" skip with such power (nearly a foot in height), with such rapidity, and so many times consecutively, that it is often difficult to catch them.

[To be continued.]

XXX.—*On the Homologies of the Male and Female Flowers of Conifers.* By ANDREW MURRAY, F.L.S.

[Plate X.]

NOTWITHSTANDING the numerous analyses to which the flowers of Conifers have been subjected, the opinion of botanists regarding the significance of their parts is by no means unanimous. Any additional light upon the subject should therefore be welcome.

The hot and long continued summer of 1865 seems, by ripening the wood, to have induced a more plentiful flowering of Conifers this year than usual—many species which had not previously flowered, or at least not previously produced male flowers, having done so this summer. The study of some of these has presented the relations of the different parts to me in a clearer light than any in which I have hitherto seen them placed; and I venture to submit them to the reader in the hope that I may thus contribute to the clearing up of the difficulties which surround them.

If we take the male catkin of any Cypressine Conifer, say *Wellingtonia*, which is one of those which have produced male flowers in Britain for the first time this year, we find that it consists of a few scales (Pl. X. fig. 1), with small rounded balls peeping out between them. These scales are obviously a mere continuation of the scales of the branch; but on examining them minutely,